VOL. XLVII, NUMBER 6 WHOLE NUMBER 405

THE JOURNAL
OF
THE ROYAL ASTRONOMICAL SOCIETY OF CANADA

DEVOTED TO THE ADVANCEMENT OF ASTRONOMY AND ALLIED SCIENCES

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PUBLISHED BI-MONTHLY
(*Six numbers per year*)

November-December, 1953

PRINTED FOR THE SOCIETY
15 ROSS STREET, TORONTO 2B

The Royal Astronomical Society of Canada

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PRINTED IN CANADA

THE JOURNAL
OF
THE ROYAL ASTRONOMICAL SOCIETY
OF CANADA

VOL. XLVII, No. 6 NOVEMBER-DECEMBER 1953 WHOLE No. 405

EDWIN P. HUBBLE, 1889–1953

BY C. A. CHANT

EDWIN POWELL HUBBLE, one of the few Honorary Members of the Royal Astronomical Society of Canada, was born at Marshfield, Missouri, on November 20, 1889, and died at Pasadena, Cal., on September 28, 1953—just before the end of his sixty-fourth year.

In 1910 he obtained the B.S. degree at the University of Chicago, where he became interested in astronomy. He was chosen a Rhodes Scholar, and studied law for two years at Oxford University, where he was given the B.A. degree in jurisprudence; and he remained another year as Rhodes Memorial Lecturer.

He was admitted to the bar in Louisville, Ky., in 1913 and practised law for a year; but the attraction of astronomy was so great that he gave up the law and returned to Chicago in 1914 for graduate study. He obtained the Ph.D. degree three years later, although during this time he joined the U.S. army. While in it he completed his Ph.D. thesis. He became Major of infantry with the A.E.F. in France.

In 1919 he joined the staff of the Mount Wilson Observatory at which the 100-inch Hooker telescope had been put in operation the year before. Here he remained, except for his service during 1942–45 as Chief of the Exterior Ballistics Branch at the Army Ordnance Ballistic Research Laboratory at the Aberdeen Proving Ground, Aberdeen, Md. For his contribution to the war effort he was awarded the Medal for Merit in 1946.

During the 1920's Dr. Hubble made his outstanding investigations on the spiral nebulae. He showed that they were stellar systems beyond our Milky Way, he determined their distances, and he developed the law of the red-shifts which led to the view that the universe is expanding.

Dr. Hubble had special ability and skill in taking photographs of these difficult objects, and a genius for interpreting the photographic records

which had been obtained. In the adapting of the 100-inch and the 60-inch telescopes to the securing of the spectra of faint nebulae various persons rendered assistance, but Dr. Hubble gives special credit to Milton Humason.

This work done with the 100-inch telescope clearly indicated the great desirability of a still larger and more powerful instrument, and when the evidence was presented to the Rockefeller Foundation a grant of six million dollars was authorized in 1928 for the production of a 200-inch telescope. In the designing of it Dr. Hubble rendered great assistance and when it was completed he was made a member of the staff in charge of it and carried out the first observations with it.

In the autumn of 1935 Dr. Hubble delivered the Silliman Memorial Lectures at Yale University and the volume containing them, entitled *The Realm of the Nebulae*, was published in 1936. It is an admirable presentation of our modern view of the universe, and is illustrated with many photographs of these spiral nebulae taken with the great telescopes on Mount Wilson. Later *The Observational Approach to Cosmology* was published by Dr. Hubble.

In 1924 Dr. Hubble married Grace Burke and they lived at 1140 Woodstock Drive, San Marino, a suburb of Pasadena. The couple had no children. On the day of his death Dr. Hubble was walking home for luncheon, as was his custom, and Mrs. Hubble picked him up with the car. While she was parking the car outside their home he was suddenly stricken with cerebral thrombosis.

YOUR PIECE OF THE MOON*

By R. A. McIntosh

So close is the conquest of the moon—at least in the minds of rocket enthusiasts and would-be space travellers—that disputes are already breaking out as to who will own what when man ultimately puts foot upon that arid globe. Actually, it lies within the power of all of us to select a portion of the lunar landscape and make it our own by right of exploration.

By that I mean that we could, if we wished, select a region or a number of lunar objects which we could study and map at every favourable opportunity. It is, by the way, rather surprising how infrequently any particular object is favourably placed and the telescopic conditions suitable for serious study. In the course of a few years we could thus amass a number of sketches and notes concerning the object of our choice which would make it very much our own—in the sense that we would know it much better, perhaps, than any other person in the world.

It is surprising what a great variety of material the moon has to offer us. Some will select a particular object (scarcely any have yet been thoroughly explored), some will concentrate upon the limb features (which have had very little attention). Others may specialise in a study of clefts, craters, ring plains, or the maria, where ample work remains to be done.

It is so easy to see details on the moon. I began my astronomical career by observing the full moon with binoculars to study the outlines of the maria and the distribution of the bright rays. Something a little more powerful than that is needed for serious study, but any telescope that is capable of good work on other objects is certainly capable of excellent work on the moon.

Three things normally deter amateur astronomers from selecting the moon as an object for study—they believe that the beautiful photographs taken with the world's largest telescopes reveal more than could their own modest instruments; they believe their own telescopes are too small for serious study and profitable results and, finally, they feel that the lunar detail is too difficult for them to sketch.

Actually such beliefs are quite erroneous. The world's largest telescopes are much too valuable to be used except on rare occasions to photograph the lunar surface. What these photographs record is no more than one would expect to see in the average small telescope, and they lack the

*Reprinted from *Southern Star*, June 1952.

benefit of continuity of observation which makes the amateur's observations so informative.

It is the constant returning to the same scene, observing it under every angle of illumination and libration, which enables the selenographer to build up a reasonably complete picture of the object he is studying. Do not imagine that your sketches will show the same details at every lunation. I have been sketching the lunar crater of Posidonius on every favourable occasion for more than twenty years and no two sketches are exactly alike. New objects are occasionally found and new light is often shed on long-familiar features.

Nor does one have to be a draughtsman or an artist to sketch faithfully the features he observes. A number of observers have published sketches which are by no means artistic, but they have left behind them outstanding reputations as selenographers. It is quite possible for the average observer to do the same.

Just as the eye becomes accustomed to planetary detail when one returns night after night to a study of the same planet, the hand equally becomes experienced in the delineation of objects seen. Many observers will remember that they once failed to see the faint white ovals on the equatorial zone of Jupiter which they now see prominently. They may thus be led to admit that their sketches of lunar craters, which now seem so difficult and so unlike the subject, may one day, after practice and experience, become artistic and accurate pictures. It is all a matter of practice.

Apart from an occasional wandering comet, the moon is both the nearest and most interesting astronomical object to study. The lunar section of the British Astronomical Association, which has functioned for many years, is now attempting to foster the international and world-wide observation of the moon. It is publishing an excellent illustrated quarterly journal, *The Moon*, full of sketches and observations and anyone, whether a member of the Association or not, is invited to contribute his own work for publication.

Why not stake your claim to a portion of the moon and make it your own?

COMMUNICATIONS
FROM THE
DAVID DUNLAP OBSERVATORY
UNIVERSITY OF TORONTO
Number 34

THIRTY-EIGHT NEW VARIABLE STARS IN ELEVEN GLOBULAR CLUSTERS

By Helen B. Sawyer

For many years the writer has been accumulating plates on globular clusters which have been searched for variables only scantily, if at all. These are chiefly clusters south of the equator. For some of them work was first begun by the writer at the Steward Observatory in 1939.[1]

Table I lists the clusters investigated in this paper. In successive

TABLE I
Clusters Covered by Present Variable Star Search

NGC	R.A. 1950	Dec. 1950	No. Plates	Pairs Blinked	Vars. Known	Vars. Found	Remarks
5897	$15^h\ 14^m.5$	$-20°\ 50'$	47	28	0	4	
6144	16 24 .2	−25 56	15	8	0	1	
6229	16 45 .6	+47 37	62	0	21	1	Ref. 2
6235	16 50 .4	−22 06	10	9	0	2	
6356	17 20 .7	−17 46	21	11	0	5	Also 1 field var.
6535	18 01 .3	−00 18	11	12	0*	1	Ref. 3
6712	18 50 .3	−08 47	25	11	2*	10	Also 1 field var. Ref. 3
6760	19 08 .6	+00 57	30	15	0*	4	Ref. 3
6779	19 14 .6	+30 05	170	25	11	1	Ref. 4,5.
6838	19 51 .5	+18 39	87	23	2	2	Ref. 6
6981	20 50 .7	−12 44	61	16	31	7	Ref. 7,8,9,10.

*Cluster previously listed with unpublished variables with no identifications.

columns are listed the NGC number, 1950 R.A. and Dec., the number of plates available to the writer before 1953, the number of pairs blinked, the variables previously announced and the number added by the present paper. The final column gives references to previous work. For

TABLE II

THIRTY-EIGHT NEW VARIABLE STARS IN GLOBULAR CLUSTERS

NGC	Var. No.	x″	y″	Magnitudes			Remarks
				Max.	Min.	Mean	
5897	1	−109	−201	15.8	16.5	16.15	
	2	− 57	− 97	15.8	16.4	16.1	
	3	− 40	− 4	15.8	16.5	16.15	
	4	+ 71	+ 20	15.5	15.9	15.7	Double star
6144	1	+481	−117	15.3	16.3	15.8	
6229	22	+ 4	− 7	15.2	16.3	15.85	
6235	1	− 16	+ 39	16.5	17.2	16.85	
	2	+ 58	−211	16.5	17.3	16.9	
6356	1	− 15	− 24	16.3	17.2	16.75	
	2	+101	−110	16.8	17.1	16.95	
	3	− 24	+ 45	16.0	[17.5	16.8:	
	4	+187	+ 47	15.9	[17.5	16.7:	Prec. comp. of double
	5	−255	+152	15.7	[17.5	16.6:	
	F1	−575	+114	15.6	[17.3	...	
6535	1	−197	+ 65	16.3	17.3	16.8	
6712	1	− 63	− 17	15.8	17.0	16.4	
	2	+ 71	+ 17	14.0	14.9	14.45	Found by Davis, Ref. 7
	3	− 28	− 96	16.2	17.0	16.6	AP Scuti, Ref. 11
	4	+181	− 28	16.4	16.9	16.65	
	5	+ 67	− 74	15.6	16.8	16.2	
	6	+ 18	− 39	15.6	16.6	16.1	
	7	−130	− 17	14.2	[17.0	...	
	8	+ 24	+ 60	14.6	15.8	15.2	
	9	− 1	+290	16.4	[17.4	...	
	10	− 99	+ 30	15.2	16.0	15.6	
	11	−122	−339	16.0	16.6	16.3	
	12	+ 31	+ 38	16.0	17.4	16.7	
	F1	−440	+ 36	15.2	17.4	15.8	
6760	1	+ 57	− 57	15.7	17.0	16.35	
	2	− 6	−100	16.7	17.2	16.95	
	3	+ 31	− 10	15.5	[17.4	...	
	4	+ 42	+ 39	15.4	[17.5	...	
6779	12	−244	− 95	15.6	16.4	16.0	No. 68 in Küstner's Cat. Ref. 12.
6838	1	+140	+ 24	13.5	14.9	14.2	Z Sge
	2	+ 44	−146	13.8	14.7	14.25	Baade 48[13], Cat. 4873[14]
	3	+ 44	− 70	15.2	17.0	...	Eclipsing
	4	+266	+ 31	14.7	15.3	15.0	
6981	35	+231	+ 27	16.2	17.4	16.8	
	36	− 12	0	16.0	16.8	16.4	
	37	+ 7	− 8	15.5	16.5	16.0	
	38	+ 5	− 9	16.6	17.3	16.95	
	39	+195	+243	16.8	17.6	17.2	
	40	+ 18	+ 16	16.4	17.4	16.9	
	41	− 15	− 20	16.7	17.5	17.1	

NGC 6144, only Steward plates were available; for 5897 and 6981 both Steward and 74-inch David Dunlap reflector plates. For the other clusters all the work was on David Dunlap plates, with a scale of 22″ to the millimetre.

For every cluster except NGC 6229 sequence plates have been taken by the writer and a preliminary magnitude sequence established in the cluster. As many pairs of plates as possible have been blinked, and the variables thus found have been estimated on all available plates. Their positions have been measured with a *réseau*.

Table II gives the positions of the variables in each cluster in x and y co-ordinates in seconds of arc. A total of 38 new variables has been found in the clusters, plus two at some distance which are listed as field variables. For six of these clusters there have been no variable stars with published positions. For the sake of completeness, variables previously assigned letters on the standard system are also given a number when they lie within the visible limits of the cluster. The observed maximum and minimum magnitudes from the available plates are given, with the mean.

Figures 1 and 2 consist of photographs giving the identification of the variables in the clusters NGC 5897, 6235, 6356, 6535, 6712, 6760, 6838, and 6981. For the first six of these clusters no large scale photographs exist in the literature. For all these photographs north is up, and the scale is indicated for each cluster.

In addition to the work on the variables, a determination of the magnitudes of the brightest stars has been made in seven of the clusters. This material is summarized in Table III, along with a recent determination

TABLE III

MAGNITUDES OF BRIGHT STARS IN GLOBULAR CLUSTERS

NGC	Total No. Vars.	Mean Sel. Vars.	Magnitudes			C.E.	Remarks
			25 B.S.	6th	30th		
5897	4	16.13	15.26	14.9	15.5	+.05	Exc. agreement
6144	1	15.8	15.76	15.2	16.3	+.15	" "
6235	2	16.87	16.24	16.0	16.5	+.13	No previous mags.
6356	5	16.8	16.38	16.1	16.8	+.32	Br. st. 0.78 brighter
6535	1	16.8	15.97	15.4	16.4	+.13	Exc. agreement
6712	12	16.52	15.35	14.9	15.7	+.32	Br. st. 0.75 brighter
6760	4	17.0:	16.77	16.4	17.0	+.64	No previous mags.
6838	4	...	14.82	14.2	15.3	...	Cuffey, Ref. 16
6981	39	16.79	15.86	15.53	16.20	+.07	Rosino, Ref. 10

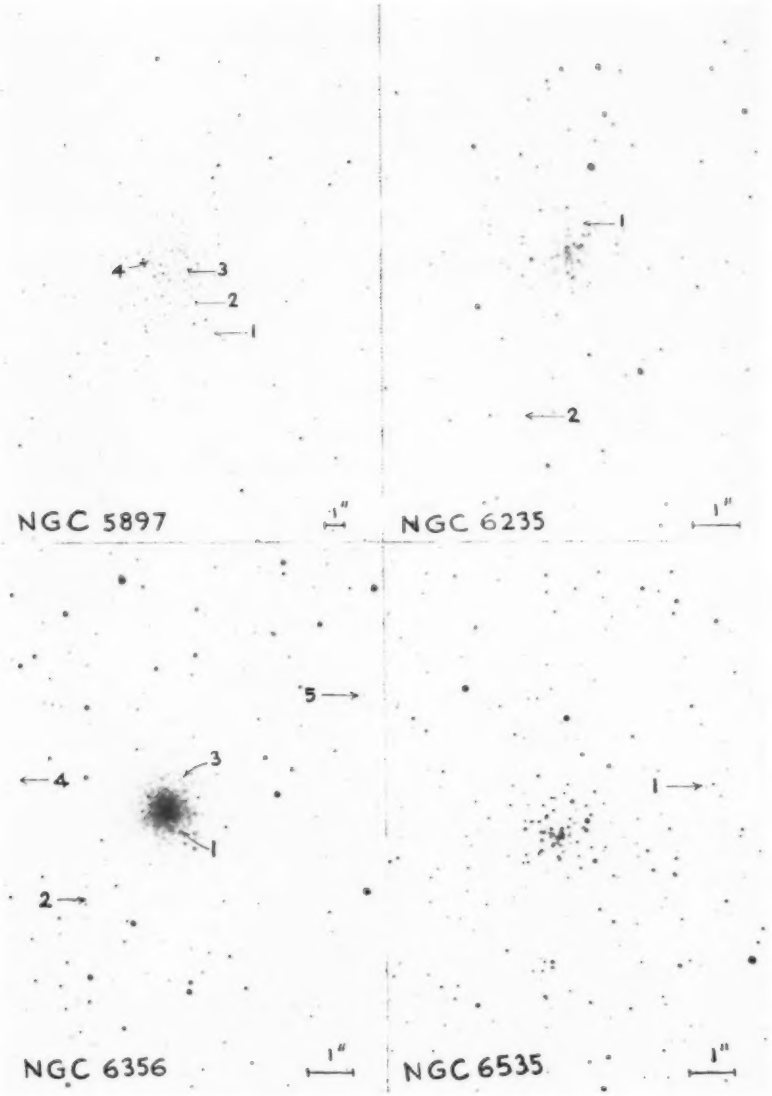

FIG. 1—NGC 5897, Steward Plate 4390, 1939 June 19, 35 min. exp. NGC 6235, Dunlap Plate 14632, 1948 July 9, 24 min. exp. NGC 6356, Dunlap Plate 12366, 1946 July 4, 14 min. exp. NGC 6535, Dunlap Plate 14628, 1948 July 9, 16 min. exp. For each cluster north is up, and the scale is indicated.

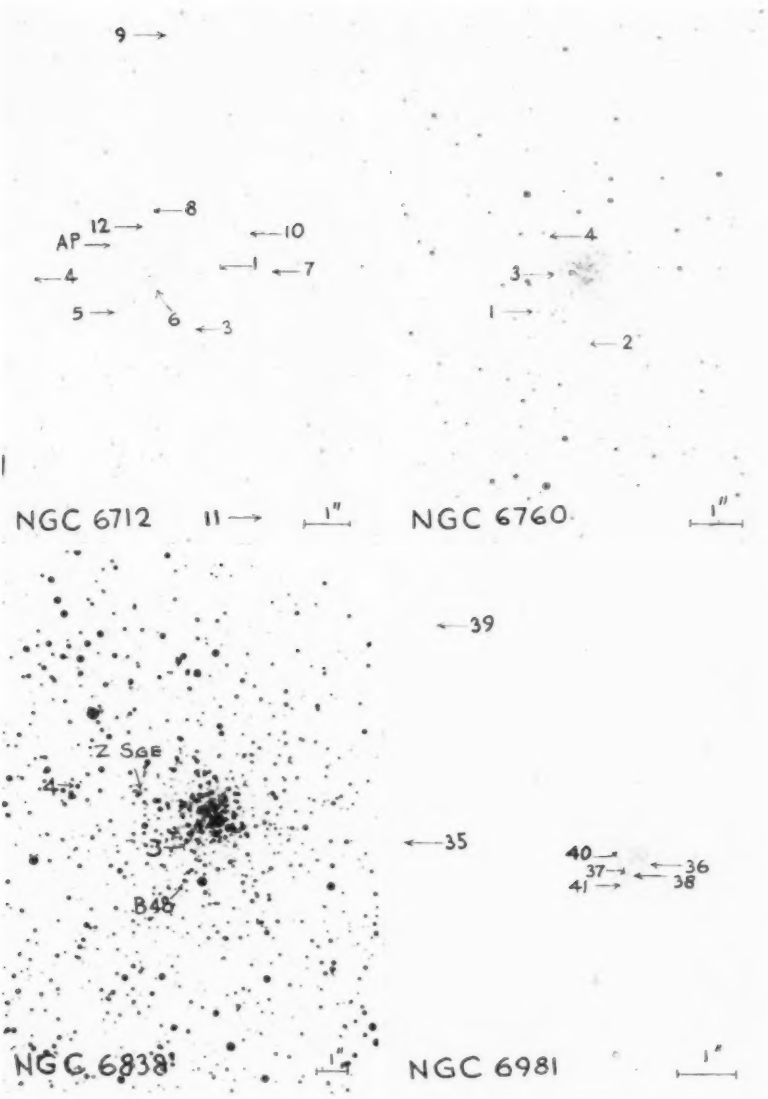

FIG. 2—All Dunlap plates. NGC 6712, Plate 12287, 1946 June 29, 16 min. exp. NGC 6760, Plate 8023, 1942 July 16, 22 min. NGC 6838, Plate 13410, 1947 June 18, 10 min. NGC 6981, Plate 7968, 1942 July 13, 20 min. exp. For each cluster north is up, and the scale is indicated.

for NGC 6981 by Rosino.[10] Successive columns give the total number of variables now known, the mean magnitude of selected variables that might be RR Lyrae stars, the magnitudes, as determined by the writer for the 25 brightest stars, the 6th and 30th brightest, the colour-excess of Stebbins and Whitford,[15] and comments on the agreement of the bright star magnitudes with previous determinations. This table is of special value in that the bright stars and variables have been estimated on the same magnitude scale. The table will have more significance however, when, for some of these clusters there is more certainty that the variables are RR Lyrae stars belonging to the cluster.

In general the magnitudes of the bright stars agree remarkably well with those previously determined by Shapley[17] and assistants, in spite of the fact that different sequences and a different selection of bright stars have been used. For NGC 6356, however, the magnitude of the 25 brightest stars is 16.38 against a former determination of 17.16; and for NGC 6712 it is now 15.35 against 16.10 formerly.

General comments on the individual clusters of this paper follow:

1. *NGC 5897.* This is a large, loose globular cluster, with an angular diameter by Mowbray of 8′.7. In spite of abundant plates and an intensive search, however, very few variables were found, and these appear to be RR Lyrae stars. In this cluster about 400 stars were examined down to magnitude 16.5.

2. *NGC 6144.* This is a faint object and was not sufficiently exposed on the available Steward plates of half-hour exposure time. It is apparently a giant-poor cluster, and only a few stars could be examined.

3. *NGC 6229.* In this cluster investigated by Baade,[2] a variable in the central region was noted by chance. Its magnitude indicates that its period may be greater than a day.

4. *NGC 6235.* This cluster is still in a somewhat uncertain category regarding classification as globular or galactic.[19] The two new variables, for which the magnitudes are the same, may help to indicate that it belongs in the globular classification.

5. *NGC 6356.* This cluster deserves to be better known among the globulars. It is one of the most beautiful globular clusters in the sky, very rich and highly condensed, situated in a region of considerable absorption. There is no previous record of a variable search in it. A telescope larger than the 74-inch reflector would be useful for this compact object. There is no doubt that its modulus is much smaller than that previously given, which was a determination of low weight.

6. *NGC 6535.* For many years Mount Wilson Observatory has listed one unpublished variable in this sparse cluster, but no positions have ever been given for it.

7. *NGC 6712.* One variable was found in this cluster by Miss Davis,[7] and Oosterhoff[11] has investigated AP Scuti which is well within the cluster limits. Mount Wilson has noted some unpublished variables. This is an exceedingly rich field for variables. The writer will keep the new variables under investigation until the periods are determined.

8. *NGC 6760.* This is a faint and difficult object, with a very large colour-excess. No individual magnitudes have been published in it previously. Two unpublished variables have been listed by Mount Wilson, but no co-ordinates given.

9. *NGC 6779, Messier 56.* From previous work on this cluster the writer has found one additional variable not included in her early paper, or that of Rosino.

10. *NGC 6838, Messier 71.* This cluster has, in recent years, been shifted from the galactic to the globular category.[19] The magnitudes of the bright stars have been measured by Cuffey,[16] who has kindly supplied the writer with additional information. The writer is also indebted to Ivan King for information on suspected variables, largely outside the actual cluster region. The region was first searched for variables by Baade[13] some years ago, and quite a number of eclipsing stars found. Two of the known variables are well within the cluster limits and should prove interesting stars. Of the two new variables found by the writer, one appears to be an eclipsing star, but its period is not yet determined. The four variables are so diverse in type that no significant mean magnitude can be derived for them as yet.

11. *NGC 6981, Messier 72.* A total of 31 variables and 3 suspected was known from Mount Wilson work of Shapley,[8] Miss Davis,[7] and Miss Ritchie.[9] Many of these have recently been studied by Rosino.[11] A substantial series of plates, blinked at the David Dunlap Observatory, has added 7 more variables.

In conclusion I wish to express my gratitude to Dr. E. F. Carpenter for the use of the 36-inch Steward reflector in 1939; and for observational assistance with the 74-inch David Dunlap reflector to various members of the staff, especially Miss Ruth J. Northcott, Mr. Gerald F. Longworth, and my late husband, Dr. Frank S. Hogg.

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October 1953.

THE QUADRANTID METEOR SHOWER

By Peter M. Millman and D. W. R. McKinley*

Abstract

Radio observations of the 1951 Quadrantid meteor shower yield a mean geocentric meteor velocity of 40.9 ±0.5 km./sec. The observed duration of the shower was five hours. Using the radio determinations of velocity and time of peak activity, together with a mean radiant position based on data from other sources, an orbit has been computed. The eccentricity of this orbit is 0.74, the inclination 70°, and the period 7.2 years; hence it is similar to the orbits of other meteor showers and short period comets.

Introduction

For over one hundred years the first few days of January have been noted as the period of a brief but marked meteor shower. These meteors are known as the Quadrantids and were named after a constellation "Quadrans Muralis" which is now obsolete. A portion of a 19th century star map printed in England by Smith and Son, 172 Strand, is reproduced in figure 1. This shows Quadrans between the constellations of Draco and Boötes, and just to the east of the handle of the Big Dipper.

A useful summary of the history of the Quadrantid meteor shower was published by Fisher in 1930.[1] From an examination of the observed rates between 1863 and 1927, and by noting some Quadrantid velocities determined in England, Fisher suggested a period of 14.6 years for this shower. He recognized, however, the great uncertainty of this value. Since 1930 a number of papers dealing with the Quadrantids have appeared. In most cases these have dealt with rates and radiant positions. Where orbits have been computed these have generally been based on the assumption of a parabolic velocity. A rather ingenious attempt to estimate the Quadrantid meteor velocities has been made by Rigollet.[2] He observed the diurnal motion of the radiant as determined by the plots of telescopic meteors and decided that, though the results were not conclusive, they favoured a geocentric Quadrantid velocity less than 40 km./sec. and suggested a short period for these meteors. Ellyett and Davies,[3] using radio techniques, found velocities between 30 and 40 km./sec. for 19 meteors observed Jan. 3/4, 1948. Their modal velocity was 34–35 km./sec. A more recent summary from Jodrell Bank[4] gives a

*Contribution from the Dominion Observatory, Ottawa, Canada and from the Radio and Electrical Engineering Division, National Research Laboratories. Issued as contributions from the Dominion Observatory, vol. 2, no. 15 and as N.R.C. no. 3135.

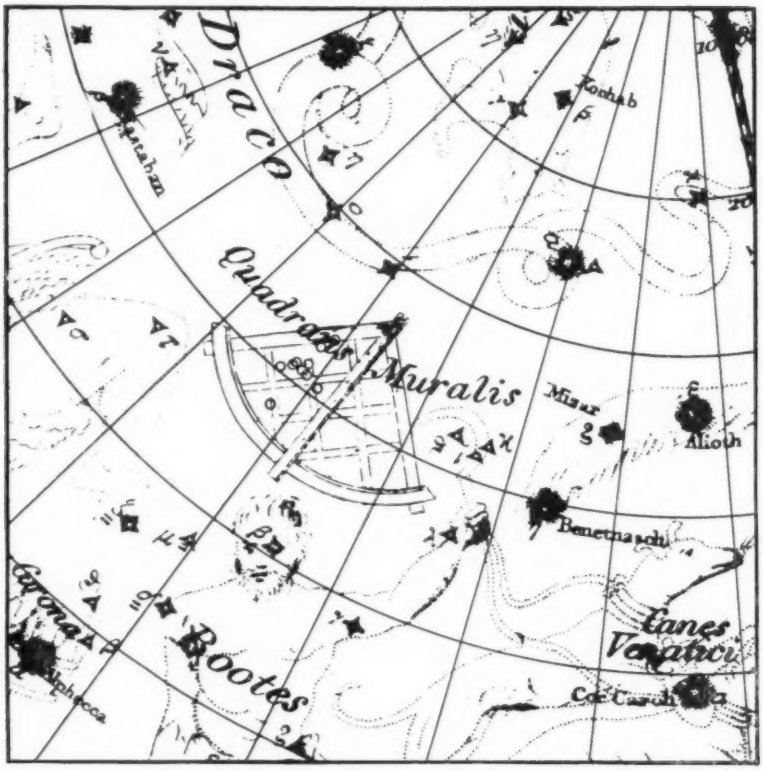

FIG. 1—Old star map showing location of the obsolete constellation Quadrans Muralis. Co-ordinate lines for 1950 have been added and radiants from Table III plotted as open circles.

somewhat higher Quadrantid velocity, and Jacchia[3] has published one photographically-determined velocity.

OBSERVATIONAL PROGRAMME

In January of 1951, radio, photographic and visual observations of this shower were planned at Ottawa in connection with the combined meteor programme being carried out by the Dominion Observatory and the National Research Council. Since new moon occurred on Jan. 7 this was a particularly favourable year for such observations. Unfortunately, as so frequently happens in the case of Quadrantid meteors, the weather

prevented any visual or photographic work. Successful radio observations were secured, however, using the Doppler amplitude-time method of recording meteor echoes, supplemented with information from the Ottawa radar records. These techniques have already been described in previous papers.[6,7]

Since the peak of the 1951 Quadrantid shower was expected at Ottawa during the early evening hours of Jan. 3, the radar and Doppler equipments were operated from 0900 hrs. to 2400 hrs. E.S.T. on that date. Despite a number of breakdowns due to power failure and other causes a total of 140 meteor velocities was measured from the Doppler records, covering the period 0944 to 1925 hrs. E.S.T. After 1925 hrs. the Doppler film record was defective, but the radar record continued until 2400 hrs.

Shower Velocity

The velocity distribution, in 5 km./sec. steps and hourly intervals, is listed in Table I. An abnormally large number of meteors with

TABLE I

Hourly Velocity Distribution—Jan. 3, 1951

Hours E.S.T. \ Vel. km./sec.	15—19	20—24	25—29	30—34	35—39	40—44	45—49	50—54	55—59	60—64
9—10	—	—	—	—	1	1	1	—	—	—
10—11	—	—	1	—	—	—	1	—	2	2
11—12	—	—	—	1	—	—	—	—	—	1
12—13	—	—	—	1	1	—	—	—	1	—
13—14	—	—	—	—	—	1	—	—	—	—
14—15	—	—	—	—	—	5	1	—	—	—
15—16	—	—	1	—	3	8	—	—	—	—
16—17	—	1	—	—	7	42	—	—	—	—
17—18	—	1	—	—	3	20	1	—	—	—
18—19	1	—	1	2	4	17	2	—	—	—
19—20	—	1	—	—	1	3	—	—	—	—
Totals	1	3	3	4	20	97	6	—	3	3

velocities in the vicinity of 40 km./sec. appeared between 15 and 19 hours. By comparing the velocity distribution of Table I with normal non-shower distributions for January and February,[7] it may be concluded that 98 to 99 per cent. of these meteors are non-sporadic and belong to a specific shower.

In figure 2 the frequency distribution of velocities in the range 32–47 km./sec. for the period 1434–1925 hrs. has been plotted in one-kilometre steps. We may consider that this histogram represents the observed distribution of Quadrantid meteor velocities to a high degree of purity. The mean velocity of 115 meteors in the selected range 37–45 km./sec. is

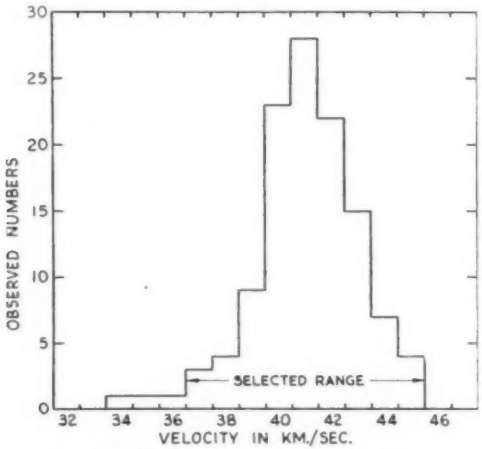

FIG. 2–Distribution of meteor velocities between 32 and 47 km./sec., observed in the period 1434–1925 hours E.S.T., Jan. 3rd, 1951.

41.15 km./sec. (p.e. of the mean is ± 0.10 km./sec.) and this has been adopted as the uncorrected observed velocity, V_{ob}, for this shower.

V_{ob} must be corrected for a number of factors to determine the true geocentric velocity, V_G, of the shower. The first of these is a correction to allow for the spacing between the Doppler transmitting and receiving stations. If the position of each meteor were known this correction could be applied to the individual cases. However, in these observations, only the mean location of the observed Quadrantids could be deduced from a knowledge of the radiant position. For velocities measured in the period 1400–1925 hrs. E.S.T., when most of the Quadrantids were recorded, the correction charts indicated an average correction of -0.25 km./sec. This correction may conveniently be called station correction. We then have the observed velocity, V_o, as $41.15 - 0.25 = 40.90$ km./sec.

The second correction to be made is that for deceleration in the atmosphere. The observed meteors have been slowed down by collisions with the air particles before their velocities are measured. To determine this correction we have used the equation given by Whipple (eqn. 16a, p. 530,

ref. 8). This equation requires a knowledge of the meteor heights, and the mean meteor mass and deceleration at the time the velocity is recorded.

Since the mean height of the Perseid echoes has been found to be 102.6 km. and of the Geminid echoes 97.0 km.,[9] a height of 100 km. was adopted for the Quadrantid echoes, the Quadrantid velocity being intermediate between the velocities for the other two showers. From previous experience with the Doppler equipment it was concluded that the majority of meteors observed were of 4th or 5th absolute visual magnitude.[7] On the basis of the physical theory of meteors this corresponds to an approximate mass of 0.001 gm. for meteors with velocities near 40 km./sec. The deceleration, V_o', corresponding to the instant at which the velocity was measured (assuming a height of 100 km.) was derived from the standard formula. The most recent determination of air density from meteor theory[5] was used. This gave V_o' as 2.85 km./sec./sec., which was adopted for our Quadrantid observations.

These values for mean mass and deceleration were checked by averaging the masses and measured decelerations from the photographic meteor results. Taking meteors with observed velocities near 40 km./sec. from Jacchia's tables,[5] and reducing all data to a height of 100 km. and an absolute visual magnitude of +4.5, we find almost exactly the above values for mean mass and deceleration. It appears then that our adopted figures for the Quadrantids are reasonable.

Taking the other necessary constants in Whipple's equation as determined by Jacchia[5, 10] we obtain +1.35 km./sec. for the deceleration correction, which represents the integrated effect of the deceleration from the time the meteor first enters the earth's atmosphere until it is observed. We now have velocity for no atmosphere, V_∞, as 40.90 + 1.35 = 42.25 km./sec.

The third correction is for the acceleration produced by the earth's gravitational attraction, −1.50 km./sec. Finally we have a small correction for the rotation of the earth on its axis. This was computed as +0.15 km./sec. To summarize:

Uncorrected observed velocity, V_{ob}	41.15		km./sec.
Station correction	−0.25		
Observed velocity, V_o		40.90	
Deceleration correction	+1.35		
No atmosphere velocity, V_∞		42.25	
Correction for earth's attraction	−1.50		
Correction for earth's rotation	+0.15		
Geocentric velocity, V_G		40.90	km./sec.

Considering all sources of systematic and accidental error this figure is unlikely to be in error by more than ± 0.5 km./sec.

Time of Shower Maximum

The histogram of figure 3 shows the observed hourly rates of meteor echoes with velocities between 37 and 45 km./sec. for the period 0944 to 1925 hrs. E.S.T. An arbitrary interval of 32 minutes was used, except for the early part of the observations. The observed rates from 0944 to 1430 hrs. were about normal, judged from similar observations made during non-shower periods at this time of the year, but a large increase in the rates is apparent after 1430 hrs.

The dashed curve in figure 3 is the relative probability function for the Ottawa Doppler equipment.[7] This curve has been located on the time

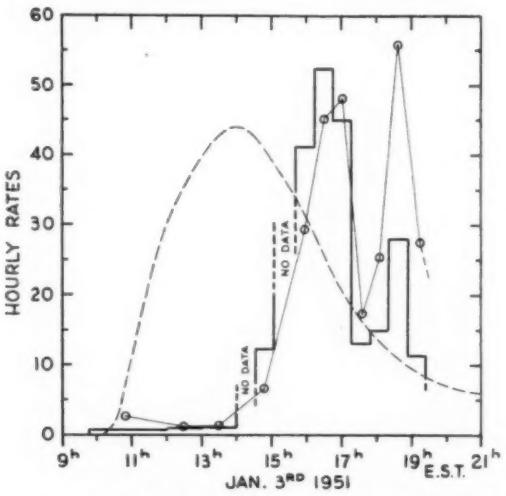

Fig. 3—*Heavy line*: observed hourly rates of meteors with velocities in the range 37–45 km./sec. *Dashed curve*: relative probability function for the Ottawa Doppler system. *Circled points*: relative hourly rates corrected for radiant elevation using the probability function.

axis by using the radiant co-ordinates adopted later in this paper. It is seen that between 1200 and 1500 hrs. a very high hourly rate of Quadrantid meteors should have been observed if the radiant had been as active as it was between 1500 and 1900 hrs. Applying the probability function to the observed rates we obtain the graph through the circled

points which represents the corrected radiant activity in relative units.

The activity was decreasing at 1925 hrs., after which the Doppler record was no longer available. However, an examination of the hourly rates from the radar record up to 2400 hrs. confirmed the conclusion that the shower activity had fallen to negligible proportions after 2100 hrs. The time of peak activity, as computed from the corrected data, is 1729 hrs. E.S.T. Jan. 3, 1951, corresponding to longitude of the sun 282° 45'.1.

Solar longitudes at shower maximum, as determined by previous visual observations and reduced to epoch 1951, are listed in Table II. It is

TABLE II

Longitude of the Sun at Quadrantid Maximum

	$\lambda\odot$ (1951)
Analysis by Davidson, 1913[11]	282° 32'
Observations by Dole, 1933[12]	282° 45'
Analysis by Prentice, 1940[13]	282° 58'
Observations by Rigollet, 1947[14]	282° 54'
Mean	282° 47'

evident that the mean of these earlier determinations agrees very well with our value from the radio results. A solar longitude of 282° 45' was adopted for the time of maximum of the Quadrantid shower in 1951.

Radiant Position

With the above values of geocentric velocity and time of shower maximum it seemed worth while to compute a mean statistical orbit for the Quadrantids. The shower activity was too brief and the radiant too low in the sky to permit an accurate determination of position by the radar technique previously used at Ottawa. It was necessary, therefore, to find a radiant from earlier visual and photographic results. Since the main Quadrantid shower is of very short duration a radiant determined in this way will have greater significance than in the case of a shower that is active over a long period of time.

Observed Quadrantid radiants from various papers, corrected as far as possible for the earth's attraction and rotation, and converted to epoch 1951, are listed in Table III. These positions have been plotted on the map of figure 1 as small circles. A mean position of R.A. 231.°5, Dec. +51.°0 has been adopted as a satisfactory radiant for statistical purposes.

TABLE III

QUADRANTID RADIANTS

	R.A.(1951)	Dec. (1951)
Mean, 84 visual radiants, 1863—1927[1]	230.°9	+50.°8
Mean, 30 visual radiants, 1910—1927[1]	232.°4	+51.°0
Radiant assumed by Davidson, 1913[11]	232.°8	+50.°2
Real paths of 13 meteors, 1889—1918[1]	231.°5	+51.°3
Photographic radiant, 1929[15]	232.°2	+48.°1
Radiant by Bakherev, 1946[16]	231.°5	+50.°9
Radiant by Rigollet, 1947[14]	230.°8	+53.°5
Telescopic radiant by Rigollet, 1947[14]	232.°5	+50.°8
Telescopic radiant by Rigollet, 1948[2]	229.°5	+50.°7
Radiant found in U.S.S.R., 1949[17]	231.°0	+53.°0
Mean values	231°.5 ± 0.20	+51°.0 ± 0.25

ORBITAL ELEMENTS

Using $V_G = 40.90$ km./sec., longitude of sun at shower maximum 282° 45′, corrected radiant R.A. 231.°5, Dec. +51.°0, a mean orbit for the Quadrantid shower was computed. This gave the following elements:

Semi-major axis	a	3.74
Eccentricity	e	0.738
Angle node to perihelion	ω	172.°6
Node	Ω	282.°75
Inclination	i	70.°25
Period	P	7.23 years

This orbit has been plotted in figure 4. It is of the same general nature as the orbits of other meteor showers and short period comets.

CONCLUSION

This study of the Quadrantid shower was virtually completed in the spring of 1952 and since then additional observations from Harvard and Jodrell Bank have been published.

Jacchia[5] has published a photographic Quadrantid velocity, $V_\infty = 44.07$ km./sec., Apparent Radiant (1950) R.A. 228.°2, Dec. +48.°3. By private communication from Jacchia we have the following orbital elements for this meteor: $a = 3.42$, $e = 0.715$, $\omega = 167.°9$, $\Omega = 282.°15$, $i = 73.°8$, $P = 6.33$ years. This orbit is very similar to our statistical mean orbit.

Hawkins and Almond[4] at Jodrell Bank have published an orbit with a much lower eccentricity, 0.46, and shorter period, 2.4 years. This is based

on an observed radio velocity, $V_o = 38.5$ km./sec., determined from 62 meteors observed in 1948 and 1951. The discrepancy between this value and our radio velocity may arise from the fact that the English observations are spread over a period of 10 days while our velocity measures were all made within 5 hours. It is possible, as Hawkins and Almond themselves suggest from their radiant determinations, that their data contain more than one centre of radiant activity. From their published velocity distribution it would also appear that more than one velocity component may be present.

Hawkins and Almond list 282.°1 as the mean solar longitude for their

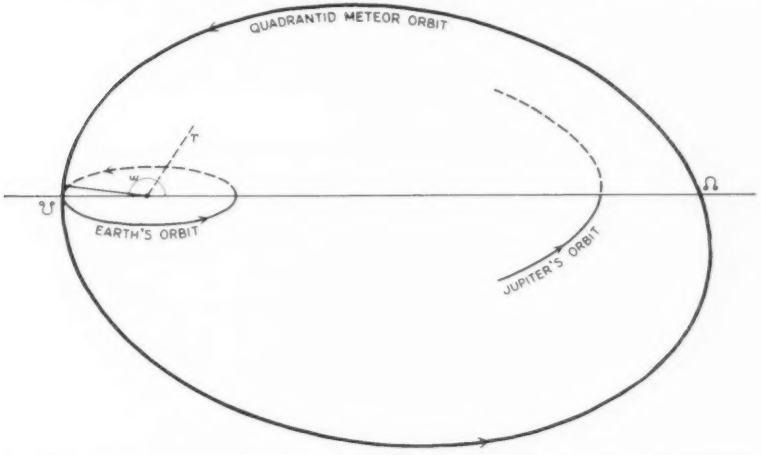

FIG. 4—Computed Quadrantid orbit plotted in plane of paper. The planetary orbits, inclined to this plane by approximately 70°, have been projected on it.

Quadrantid observations on Jan. 3, 1951, when they obtained their greatest number of Quadrantid echoes. This longitude corresponds to 22^h E.S.T., Jan. 2. Though the Ottawa radio went on the air prior to 10^h E.S.T. on Jan. 3, no evidence of the shower appeared until after 14^h. This seems to indicate that the English observations may refer in general to a different section of the Quadrantid shower to that observed at Ottawa.

In conclusion it may be noted that, though some observers have found considerable evidence for auxiliary radiant activity near the time of the Quadrantid shower maximum, the main nucleus seems to be concentrated within fairly narrow time limits, confirming the general conclusions of Prentice and others. It has been found possible to derive reasonably

good statistical mean values for radiant position and time of shower maximum. Because of the small dispersion about the mean the Ottawa Quadrantid velocity, based on 115 meteors observed in 5 hours, is believed to be the best available statistical value.

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REVIEW OF PUBLICATIONS

Astrophysics—The Atmospheres of the Sun and Stars by L. H. Aller. Pages ix plus 412; 6¼ × 9¼ in. New York, The Ronald Press, 1953. Price $12.00.

For many years there has been a conspicuous need for a book, written in English, which would discuss the theory of the atmospheres of the sun and stars in a manner suitable for graduate students and astronomers in general. This new book fills this need admirably as is evident from the fact that it already has been used extensively, in mimeographed form, by students for many years.

The first chapter is a survey of the basic astronomical data which are of use in astrophysics. This includes brief discussions of the spectral sequence, the masses and luminosities of stars, the colour of stars, etc. Many will wish that this chapter could have been longer. The following four chapters outline the physics which is needed for the study of stellar atmospheres. There are discussions of atomic and molecular spectra, gas laws, turbulence, excitation, ionization, dissociation, and radiation theory. The student will find these chapters useful, not so much for learning or understanding the theory, but rather as a summary of the important results and as a handy place to check up on the standard astrophysical notation which often differs greatly from that used in physics.

Chapters 7 and 8, perhaps the most important in the book, deal respectively with the continuous and Fraunhofer spectrum of stars. The first of these chapters discusses the continuous absorption coefficient and its effect on the continuous spectrum of stars, colour temperatures of stars, the equation of transfer and various methods of solution such as the Eddington approximation and the Chandrasekhar method, and model stellar atmospheres for early and late type stars. The following chapter includes such topics as the line absorption coefficient, the equation of transfer for line radiation, computed line profiles, the curve of growth and its applications.

The final chapter is concerned with solar phenomena insofar as they are connected with the atmosphere of the sun. Such topics as sun-spots, magnetic fields in sun-spots, prominences, flares, the chromosphere, the corona, and radio-frequency radiation, are discussed.

The author has employed a number of attractive features in this book, some of which should be mentioned. Throughout the book the author has used numerical examples, often ones taken from his own research. For

students who have not yet done such research, these examples will help to familiarize him with the methods used. The author has also incorporated many of the recent advances in the field of astrophysics. Such topics as radio-frequency radiation and stellar magnetic fields have been given suitable space in the book. The bibliography following each chapter has been arranged according to specific topics and should prove valuable to anybody working in the field. In conclusion, this book is one which astronomers will want to own and one which every graduate student should study thoroughly. J. B. O.

Starting Astronomy by E. O. Tancock. Pages viii plus 122; 9 × 5¾ in. George Philip and Son Limited, London, 1951.

Some of the material in this book has been taken from "The Elements of Descriptive Astronomy" which was printed in 1924 by the Clarendon Press, but which has been allowed to lapse after three reprintings of the revised edition.

Although the title of this book is "Starting Astronomy", it is felt by this reviewer that the vocabulary of astronomy needs to have been met before reading this book. The author's object is to help those who wish to understand the principles of astronomy and to observe with very small telescopes or none at all. Following a brief introduction to the solar system are chapters on the sun, moon, aspects of the sky, planets, comets and meteors, stars and nebulae. Final chapters cover the chief stars and constellations and conspicuous star clusters and nebulae of interest to the observer. Objects in the far southern hemisphere are included. The last chapter is on telescopes and the spectroscope. Appendices include discussions of the tides and time, and exercises and practical work.

A few errors and inconsistencies were noted: the period of rotation of Venus is usually quoted as being 30 days, although there is some uncertainty in its value (p. 5); the spelling *co-latitude* and *colatitude* appear on one page (p. 33); the dates of the solstices are different on pages 37 and 41. There is considerable uncertainty that Mars has "an atmosphere containing water vapour" (p. 49) and that it "probably has vegetation" (p. 50); these statements are misleading. The author states that hardly any of the globular clusters are in the Milky Way (p. 68), although more than half appear in the Scorpius–Sagittarius region; as viewed from space the globular clusters lie in a roughly spherical space around the centre of the Milky Way system.

The thoughtful beginner should find this little book both helpful and interesting. R. J. N.

VARIABLE STAR NOTES

American Association of Variable Star Observers

By Margaret W. Mayall, *Recorder*

The Annual Meeting of the A.A.V.S.O. was held at the Harvard College Observatory on October 9 and 10, 1953. More than 70 members and friends gathered on Friday afternoon—the Ralph Buckstaffs coming from as far north-west as Oshkosh, Wisconsin, and Sr. Domingo Taboada and his nephew Angel south-west from Puebla, Mexico; all in all a spread of nearly 29 degrees in longitude and 25 degrees in latitude.

Dr. Albert Linnell, from Amherst College, gave an excellent lecture Friday evening on "Electronics and Variable Stars." It is a rare thing to hear such a clear explanation of the workings of the phototube and amplifying systems. Electronic equipment will make possible a valuable expansion of A.A.V.S.O. programmes, and will enable us to add eclipsing stars and other variables with small rapid changes. But it can never replace the long, continuous visual observations needed for the long period variables.

At the business session on Saturday morning, we had the sad duty of announcing the death of one of our observers, Mr. Hensley Cobb of Great Yarmouth, England.

Mr. A. R. Ball of Milwaukee, Wisconsin, has joined the Association as a life member. He has contributed observations for many years. Fourteen new annual members were elected: Harry L. Bondy, New York; Tucker Carrington, Connecticut; O. M. Erpenstein, California; Mack Lee Felts, Texas; Richard R. Fink, Wisconsin; Guy A. Logan, North Carolina; Eugene M. Lonak, Illinois; John Neff, Wisconsin; Edgar M. Paulton, New York; Ronald Royer, California; Ronald A. Schorn, Illinois; Alan H. Shapley, Washington D.C.; John M. Spooner, Indiana; and W. W. Zimmerman, Kansas.

Newly elected Council members were: Jocelyn Gill (second term), Walter P. Reeves, Francis J. Reynolds, and Charles H. Smiley. The officers for the year 1953–54 are:

President:	Martha Stahr Carpenter
1st Vice President:	Charles H. Smiley
2nd Vice President:	Cyrus F. Fernald
Secretary:	Clinton B. Ford
Treasurer:	Percy W. Witherell
Recorder:	Margaret W. Mayall

Reports from the various divisions and committees showed continued activity on all sides. Mr. Richard Hamilton, the Chart Curator, issued nearly four thousand 8×10 charts to observers during the year. The new chart catalogue has been sent to observers who requested it. The Auroral Committee is making plans for the "Geophysical Year," set for 1957. It is expected that the new method set up by Mr. Donald Kimball's committee, for recording aurorae, will be adopted internationally.

During the year 1952–53, 144 A.A.V.S.O. observers submitted 62,223 observations of variable stars. Of these observers, 48 from 21 countries outside the U.S.A. made 49 per cent. of the observations. Eight observers in South Africa topped the list with 10,407 observations; three in Greece made 9,636; two in Switzerland made 2,889; and one in Sweden made 2,118 observations.

There was a surprise this year in the observer who sent in the greatest number of observations. Demetrius P. Elias of Athens, Greece, made a leap to first place with a record number of 8,363 observations. Reginald P. de Kock of South Africa was second with 6,467; Cyrus F. Fernald of Wilton, Maine was third with 3,808; Edward G. Oravec of Tuckahoe, New York, was next with 3,419; and fifth place was taken by Curtis E. Anderson of Minneapolis, Minnesota, with 2,955. Eight observers contributed between 1,000 and 2,000 observations, and 126 had less than 1,000. The 122 observers who sent in less than 500 observations apiece contributed more than 20 per cent. of the total received; good proof of the value of a small report when it is combined with others.

The total number of observations has now passed the one-and-one-half million mark: at the end of the fiscal year, September 30, 1953, it had reached 1,515,665. Curtis E. Anderson of Minneapolis was the lucky observer. His observation of Nova Herculis 1934 (DQ Her) on June 10, 1953 was *observation number 1,500,000* as received by the Recorder.

The climax of an annual meeting of the A.A.V.S.O. is always the famous "Highlights of Astronomy" given by Dr. Shapley at the Annual Dinner. We list them below as he gave them, but not, as he pointed out, necessarily in order of importance.

Highlights of 1952–1953. 1. A conference this past summer of astronomers at the Lowell Observatory, Flagstaff, under an arrangement of the National Science Foundation, which made definite progress in discussions of the advisability of establishing in the near future a National Research Observatory at the best possible site, probably in the South-west, with special reference to the requirements of photoelectric programmes.

2. The beginning of the construction of the world's greatest "inch" for telescopic exploration, namely, the 3,000-inch steerable radio telescope at Jodrell Bank near Manchester, England, where epochal work will be continued on nearby meteors and remote radio stars. Dr. Lovell reports that the giant instrument will seek to penetrate the dust clouds in the Milky Way rift and reveal what stellar wonders lie beyond it.

3. The design and preliminary testing by Lallemand and his associates in Paris of a device for "electric photography," which holds promise of speeding up greatly the recording of faint stellar objects.

4. The attainment for the first time of the twenty-third magnitude (photographic scale) with the Hale Reflector by William Baum, who has made use of new photon counting devices in photoelectric photometers.

5. As an important step in the analysis of the structure of galaxies, the exploration by radio of the Magellanic Clouds by Frank Kerr and J. V. Hindman of Sydney, Australia, using for the first time the rapidly developing tool of 21-cm. radiation. They obtained signals from a larger area than that recorded by photographic plates and they find (*a*) internal motions of the Large Cloud, (*b*) probable orbital motions of the two Clouds with respect to their centre of gravity, and (*c*) high speed drift of both Clouds—all as indicated by the motion of their interstellar clouds of neutral hydrogen gas.

6. Further developments in the revision of the extra-galactic distance scale (first reported as a highlight last year); the new work includes contributions by Baade and his associates at Mount Wilson-Palomar, Gascoigne and Kron (working in Australia), Thackeray at Pretoria in South Africa, Weaver at the University of California, and Shapley and Nail at Harvard, who find a correction factor of 2.2 from the study of the brightest stars in the Magellanic globular clusters.

7. The measurement photoelectrically and the analysis at the McDonald Observatory by Kuiper, Harris, and Ahmad of the light variations of ten asteroids; they confirm the belief that most asteroids are irregular rotating fragments with the sun's reflected light varying with the rotation but without change in colour.

8. Studies of the night sky by Roach at Inyokern, California, in which he demonstrates the connection of the corona and the zodiacal light.

9. Pioneer theoretical work by G. C. McVittie of the University of Illinois on the application of certain Einstein relativity equations to gas dynamics, with potential usefulness in the study of interstellar material and phenomena associated with novae.

10. The detection by a research group from the Naval Research Laboratory working at White Sands, New Mexico, of the ultra-violet Lyman alpha line of hydrogen (wavelength 1216 angstroms) in the solar spectrum; they obtained this important result by using rocket-borne photon counters shot above the ozone blanket to a height of some fifty miles. William Rense and associates at the University of Colorado have confirmed the Lyman alpha observation spectrographically, also through use of high altitude rocketry.

11. The observation by Machin and Smith of the Cavendish Laboratory, Cambridge, England, of the occultation of the strong radio source in the Crab Nebula by outlying parts of the solar corona when the nebula is as much as ten solar radii from the sun, far beyond the coronal streamers that can be recorded photographically.

Nova Search Programme: During the months of August and September, 1953, reports were received from the following eleven observers. Listed for each observer is the month the observations were received, the areas observed (in italics), the number of nights the region was checked, and finally, the limiting magnitude.

BLUNCK, VICTOR H., Sept.–*8, 9, 10*: 7, 6.

DARSENIUS, GUNNAR O., Sept.–*Dome*: 8, 2; *16, 17*: 9, 6.

°DIEDRICH, DELORNE, Aug.–*Dome*: 1, 2; *94*: 2, 6; *94*: 1, 5;
Sept.–*Dome*: 1, 2; *94*: 3, 6.

°DIEDRICH, GEORGE, Aug.–*Dome*: 4, 2; *78*: 3, 6;
Sept.–*Dome*: 5, 2; *78*: 5, 6.

MAYRON, BART, Aug.–*24*: 1, 6½; *24*: 2, 3; *24*: 2, 4; *24*: 4, 6; *24*: 11, 5;
Sept.–*24*: 3, 5; *24*: 5, 6½; *24*: 8, 6.

°RICK, J. J., Aug.–*78*: 5, 4; Sept.–*79*: 1, 4.

°RICK, LOUIS, Aug.–*Dome*: 7, 2; *18, 63*: 3, 5; *18, 63*: 4, 4;
Sept.–*Dome*: 4, 2; *Dome*: 2, 1; *18, 63*: 4, 5; *63*: 2, 4.

ROSEBRUGH, DAVID W., Aug.–*Dome*: 6, 3; *Dome*: 1, 2; *1*: 1, 4;
Sept.–*Dome*: 8, 3; *1, 34*: 2, 4.

SMITH, FRANKLIN W., Aug.–*3, 4*: 4, 6; Sept.–*3, 4*: 4, 6.

WELLS, KARL A., Sept.–*1 to 22*: 10, 4.

°WHERRY, JOHN, Aug.–*Dome*: 1, 2; *39*: 1, 5.

°Black River Astronomical Society

Observations received during August and September, 1953: During August, 4,686 observations were received and in September, 7,869, making a grand total of 12,555 contributed by the following 82 observers:

Observer	August No. Var.	August No. Ests.	September No. Var.	September No. Ests.	Observer	August No. Var.	August No. Ests.	September No. Var.	September No. Ests.
Adams, Robert M.	62	183	66	174	Howell, Shapleigh W.	9	9	..	..
Ancarani, Mario	23	38	23	51	James, Robert	5	5	..	..
Anderer, Joseph A.	12	13	4	4	Jerabek, H. S.	13	16	..	..
Anderson, Curtis E.	151	1047	138	208	Johnsson, Robert G.	27	27	..	..
Archer, S.	3	46	84	104	Kato, Hiroshige	..	..	8	9
Aronowitz, Charles	17	43	15	68	Kelley, Leo A.	14	15	7	7
Ball, A. R.	11	16	..	..	Kelly, Frank J.	11	14	10	13
Beidler, Herbert B.	..	..	4	8	de Kock, Reginald P.	135	537	132	522
Blunck, Victor H.	..	..	12	27	Konig, William	7	9	..	..
Bonilla, Tony	..	..	8	19	Koons, L. Donald	..	..	30	41
Botham, John H.	..	..	16	72	Kuenzi, Edward W.	..	..	12	71
Boutell, Hugh G.	8	40	8	30	Lacchini, Giovanni B.	..	..	10	23
Buckstaff, Ralph N.	22	37	29	77	Lizotte, Eugene A.	6	10	8	14
Carpenter, Claude B.	..	..	*22	22	Lonak, Eugene	5	50	5	25
Carrington, Tucker	3	3	..	..	Miller, William A.	22	30	10	14
Chapman, Gary	..	..	4	4	Montague, Allen C.	51	84	41	55
Charles, Donald F.	34	41	13	30	Neff, John	24	31	..	..
Chester, Bryant	9	9	8	8	Oravec, Edward G.	82	288	95	339
Chiabotta, Ronald	..	..	3	3	O'Sullivan, William H.	5	9	12	19
Cragg, Thomas A.	173	182	131	145	Overbeek, Michiel D.	86	238	..	..
Dafter, Rosina	6	35	7	41	Owen, Toby	1	1	..	..
Darsenius, Gunnar O.	7	7	61	298	Parker, P. O.	36	36	42	43
Diedrich, DeLorne	2	4	2	4	Parko, Joseph E.	3	3	..	..
Diedrich, George	3	7	3	6	Paulton, Edgar M.	7	13	9	11
Elias, Demetrius P.	..	..	138	3150	Pearcy, Robert E.	6	6	6	6
Escalante, Francisco J.	61	76	35	41	Pease, Harry	4	4	..	..
Fernald, Cyrus F.	209	311	216	507	Peltier, Leslie C.	41	152	56	215
Fernald, Emily S.	..	..	5	5	Reeves, Walter P.	..	..	2	3
Ficonetti, Rene	..	..	26	34	Renner, C. J.	190	192	247	268
Focas, Joannis E.	..	..	13	16	Rizzo, Patrick V.	25	62	26	49
Ford, Clinton B.	84	96	122	127	Rosebrugh, David W.	11	62	14	118
Gaustad, John	8	8	2	2	Ruiz, John J.	1	95	1	81
Goodsell, J. G.	..	..	4	4	Schorn, Ronald A.	..	..	3	47
Greenley, Robert M.	32	33	25	25	Smits, Peter	28	41	26	58
Haberstroh, Robert A.	16	26	..	..	Strzyzewski, Eugene	9	10	..	..
Halbach, E. A.	18	24	..	..	Taboada, Domingo	19	24	19	19
Hartmann, Ferdinand	111	115	110	117	Thurn, Vincent W.	1	9	..	..
Herring, Alika K.	..	..	41	93	Venter, S. C.	61	96	74	175
Hiett, Lancaster	..	..	10	41	Vermilya, Robert	1	1	..	..
Houston, Walter	..	..	5	5	Wells, Karl A.	..	..	2	4
Howarth, Mark	15	15	15	15	Wyckoff, Jerome	37	52	30	35

Harvard College Observatory
Cambridge 38, Massachusetts
October 20, 1953

METEOR NEWS

By Peter M. Millman, *Dominion Observatory, Ottawa*

Regina Perseid Observations, 1952

During the past few years the Regina Astronomical Society has been active in meteor observing. Last year I reported on their observations made during 1950 and 1951. I have recently received a report of their Perseid observations in 1952 and summarize here the chief results of this programme.

Successful visual records were made on the three nights Aug. 11/12, Aug. 12/13 and Aug. 13/14. On the first night there was occasional cirrus and haze for short intervals. On the second night about 5/10 cumulus was encountered during the first hour and for the last 15 minutes. On the third night cumulus up to 5/10 occurred for the first 30 minutes after midnight. For the remainder of the time the sky was generally clear. The moon was at the last quarter on the first night.

The programme was in charge of Mr. J. V. Hodges, President of the Society, and Mr. R. J. Harper, Secretary. The complete list of those who took part in these observations is given below:

T. Apperley, Miss P. Binder, Miss E. Davis, D. Fast, Mrs. H. Gilbert, C. Haglund, R. J. Harper, J. V. Hodges, Mrs. J. V. Hodges, Miss F. Homan, A. Irwin, I. Lipton, Mrs. H. Lipton, Miss E. Lumsden, T. R. MacFarlane, J. McNeil, A. Nilson, Mrs. S. Nilson, J. Scott, Miss E. Stillwell, J. Thauberger, J. Toews, C. Trowsdale, H. Williams, M. Worel.

On each night the observers were divided into four groups facing the four cardinal points of the compass. A total of 19 observers participated on the first night, 13 on the second and 17 on the third. In addition there were recorders, timekeepers, and those looking after the club room. Internal nourishment in the form of hot coffee and refreshments is a very important part of all night observing activity as only in this way can one maintain full efficiency during the graveyard shift in the early morning hours.

Grand totals of 480 Perseids and 165 Non-Perseids were observed on the three nights, a very fine record. The numbers of meteors recorded in each twenty-minute interval are listed in the first half of Table I. In the second half are given the hourly rates, reduced to a standard team of six observers. From an examination of these rates it may be concluded that the highest rates would have been recorded on the night of Aug.

TABLE I

M.S.T.	Meteors Observed						Hourly Rates (six observers)					
	Aug.11/12		Aug.12/13		Aug.13/14		Aug.11/12		Aug.12/13		Aug.13/14	
	P	N	P	N	P	N	P	N	P	N	P	N
2150—2210	9	6	5	1	3	3	29	11	20	5	12	9
—2230	18	4	11	3	8	6	31	10	35	7	16	9
—2250	15	4	26	4	10	4	39	10	35	6	18	17
—2310	21	6	5	0	6	13	38	10	38	8	18	22
—2330	16	4	15	6	8	12	38	10	31	7	15	22
—2350	21	4	17	3	6	4	47	9	51	13	11	14
—0010	27	5	30	7	1	3	51	10	61	13	14	15
—0030	22	5	26	6	12	13	55	9	63	16	15	22
—0050	26	2	20	6	7	13	62	8	46	17	20	20
—0110	37	4	9	9	8	1	66	7	37	18	16	16
—0130	28	4					53	6				
0130—0150	7	0					38	4				
Totals	247	48	164	45	69	72						

P Perseids N Non-Perseids

12/13 had it not clouded up near the end of the observing period. On the third night there was a definite drop in the numbers of meteors visible. The total rates for Regina on this night are very similar to those published in the last number of the JOURNAL for the Montreal Centre, but the latter group estimated a far higher percentage of Perseids.

The magnitude distributions for the Regina observations are given in Table II. The mean magnitudes are very similar to those recorded in

TABLE II
MAGNITUDE DISTRIBUTIONS

Mag.	−3	−2	−1	0	1	2	3	4	5	Totals	Mean Magnitude
P	1	5	12	21	54	115	158	93	21	480	2.52
N				2	6	30	53	55	19	165	3.27

Montreal, which indicates that both groups were estimating meteor brightness in a similar manner, a very statisfactory situation.

Both these active groups of observers were planning to observe the 1953 Perseids and a further comparison of their results will be of interest.

NOTES FROM OBSERVATORIES

Dominion Astrophysical Observatory, Victoria, B.C.

Staff. Temporary appointments for the summer of 1953 were held at the Observatory by Professor Joel Stebbins, Professor B. N. Moyls, Mr. Hubert Reeves, Mr. K. C. McCulloch, Mr. Robert Pugh, and Mr. J. N. Merner. Miss MaryJane Stewart of Portland, Ore., spent a month at the Observatory as a voluntary assistant.

Miss Jean K. McDonald has continued to pursue the problem of constructing model atmospheres for early-type stars using the electronic computing machine at the University of Toronto and, according to recent reports, has made good progress. Mr. G. J. Odgers obtained a leave-of-absence to carry on graduate studies in the Department of Astronomy, University of California, Berkeley, commencing in August 1953. Dr. A. McKellar returned to the Observatory at the end of June.

New Office Building. The new addition to the office building was virtually completed by June, and those staff members having offices in the new section occupied their new quarters early in July. The new building relieves the previous congestion and provides adequate office space even when the staff is augmented by its temporary summer appointees. Also, it provides space for the seismographic instruments, for three laboratory rooms, for a photographic section, for storage of publications, and for much needed additional library space. Landscaping of the grounds around the building is at present under way.

Telescope and Spectrograph. Certain of the optical arrangements for the universal spectrograph have been constructed. An f:18 quartz-fluorite achromat of focal length 41 inches has been mounted and tested. In the Littrow grating spectrograph it gives a beautifully flat field and excellent definition throughout the visible and ultra-violet regions of the spectrum. A second lens with quartz and glass components, focal length 72 inches, diameter 3.75 inches, has also been installed, and, with the new and larger gratings, gives excellent performance. Dispersion in the third order of a 15,000 lines-per-inch grating with this lens is 2.8 A./mm.

As auxiliary to the telescope-spectrograph combination, a new guiding eyepiece operating through an extensible tube down the flat narrow side of the spectrograph has been found to be a great convenience. This eyepiece extension is similar in principle to that in use at the David Dunlap Observatory. A newly built and lighter slow-motion control box,

attachable to the lower end of the eyepiece extension, is also an aid and comfort to observers. The eyepiece for direct visual observations and use on public evenings has been redesigned and rebuilt. It now remains in position all the time and so can be used as an additional powerful finding telescope for faint stars.

The photoelectric photometer built last year for the 72-inch telescope has been well tested and has been used to a limited extent in five-colour photometry. With a new E.M.I. photomultiplier tube it has been shown to be capable of measuring the brightness of a 19th magnitude star.

Seismology. Messrs. W. G. Milne and J. N. Merner, in September, installed a network of three seismic stations in the Fernie-Coleman region of the Alberta-British Columbia border. This is part of a programme to investigate any possible connection between local earthquakes and "bursts" or "bumps" in the nearby coal mines.

Visitors. Recent visitors spending a few days at the Observatory have included Professor Fred Hoyle, Cambridge, England; Dr. Theodore Dunham Jr., University of Rochester, Rochester; Dr. A. R. Hogg, Commonwealth Observatory, Canberra, Australia; and Dr. Dean S. Carder, United States Coast and Geodetic Survey, Washington, D.C.

NOTES AND QUERIES

Library Hours

The library of the Royal Astronomical Society of Canada is open weekdays in the morning from 9 a.m. until 12:30 p.m., and in the afternoon from 1:30 until 3 p.m. Considerable reorganization of the library material has recently been effected, and members are invited to visit the library when in Toronto.

William R. Hossack, *Librarian.*

T Tauri and Associated Nebulosity

Just over 100 years ago an English astronomer, John Russell Hind, was the first to observe a small nebulous object near the variable star T Tauri. During these hundred years, observations have shown that this nebulosity is variable in brightness, although there is apparently no correlation between its variations and those of the star T Tauri with which it is associated. Proof of this association was found just recently when spectra of the nebulosity were compared with those of T Tauri—

they were identical. Nebulae associated with stars cooler than 20,000° K. such as T Tauri (cooler than 6000° K.) shine by reflected light alone, so the result is what one would expect.

In 1890 Burnham discovered that T Tauri itself is embedded in a small, bright elliptical nebulosity which is also variable. When a spectrum of this nebulosity alone was taken, it was discovered that it consisted of bright emission lines of oxygen, sulphur and hydrogen, common to nebulae excited by very hot blue stars. This implies that the inner and outer nebulosities at T Tauri have great differences in physical conditions, but no explanation has yet presented itself. B. R. C.

U.R.S.I. Meeting Held in Ottawa

The International Scientific Radio Union was organized in 1919 with three main aims: (1) to promote the scientific study of radio communications; (2) to aid and organize radio research requiring co-operation on an international scale and to encourage the discussion and publication of the results; (3) to facilitate agreement upon common methods of measurement and the standardization of measuring instruments. The commonly-used name of U.R.S.I. comes from the French name, Union Radio Scientifique Internationale. The International Union has seven permanent "Commissions" which carry out the organization of work in the principal technical fields. The Union holds, every two or three years, a meeting called the General Assembly—patterned in a similar way to the International Astronomical Union. The last meeting was held in Australia, the present one in Ottawa and the next one is to be held in the Netherlands in 1954.

The Canadian National Commissions are as follows:

1. Measurement and Standardization—J. T. Henderson.
2. Tropospheric Wave Propagation—J. S. Marshall.
3. Ionospheric Wave Propagation—J. C. W. Scott.
4. Atmospherics of Terrestrial Origin (combined with Commission 3).
5. Radio Astronomy—A. E. Covington.
6. Waves and Circuits—G. Sinclair.
7. Electronics—P. Bricout.

Over fifty papers were presented at the meeting; about a third were by Canadian authors from such organizations as Canadian Westinghouse Co., Defence Research Board, Dominion Observatory, T. S. Farley Ltd., National Research Council, University of Saskatchewan and University of Toronto.

In a paper entitled "The Height and Intensity of Meteoric Ionization", Peter M. Millman of the Dominion Observatory, and a regular con-

tributor to the JOURNAL, summarized the information available from radar observations of meteors. He pointed out the dependence of the height of the clouds of ionization on the size and velocity of the meteoric particles.

The brightness of the daytime sky has been investigated since 1946 by rocket-borne photoelectric photometers. This work was reported by H. D. Edwards of the Air Force Cambridge Research Center. It appears that sky brightness consists of (1) sunlight scattered by the atmosphere and (2) day air glow. Scattered light values are large at the ground but decrease rapidly at higher altitudes; at a height of about 20 miles the sky is almost black. Air glow becomes the more important factor at heights of about 22 to 25 miles. Present theories do not adequately account for the amount of air glow.

The recent work in radio astronomy at the Cavendish Laboratory at Cambridge was described by F. G. Smith. Measurements of the distribution of radio brightness across the radio source in Taurus indicate that either it is not uniformly bright and extends beyond what is observable optically or that there is a second source nearby. This radio source has been identified as the famous Crab Nebula. An attempt has been made to detect radiation at 200 mc./sec. from the Orion Nebula; as yet this has been unsuccessful.

Radio-frequency observations of solar eclipses are important in fixing the part of the sun from which enhanced solar emission comes and in determining the radio brightness distribution over the solar disk. This problem was discussed by F. T. Haddock, N.R.L., Washington. Since 1945 eight solar eclipses have been observed at two or more radio wavelengths. The techniques and methods of analysis used in these measurements were discussed with a view to making recommendations for the next solar eclipse of June 30, 1954, an eclipse which will be visible in north-eastern Canada. More about the path of this eclipse will appear in a later issue of the JOURNAL. R. J. N.

PHOTOGRAPHS OBTAINED OF FAR ULTRA-VIOLET SOLAR SPECTRUM

The ozone in the earth's atmosphere cuts off the radiation which reaches the surface at a wave-length of about 3000 A. However, University of Colorado scientists have successfully photographed the sun's hydrogen line at 1215 A. by using a rocket with a special pointing mechanism which took the photograph at a height of fifty miles above the earth's surface. This is the first time that a member of the Lyman series of hydrogen has been photographed in the sun's spectrum.

R. J. N.

Asteroid Icarus

Of the 1500 or so asteroids known, relatively few have been useful in solving problems; in general asteroids present problems. The asteroid Eros is a notable exception. From many observations of Eros at its close approach to the sun in 1930, made at different observatories scattered over the earth, the Astronomer Royal was able to arrive at the best value of the scale of the solar system yet determined. The asteroid Icarus may become equally important. The motion of Icarus may lead to an independent check of the theory of relativity. At present the observational evidence for the relativity precession of planetary orbits depends almost entirely on the rate of advance of the perihelion of Mercury's orbit. Icarus, discovered in 1949 by Baade, has the smallest mean distance from the sun of all the known asteroids and has a very high eccentricity, so that at perihelion Icarus is nearer the sun than Mercury. The predicted advance in the perihelion of Icarus is 10.05 seconds of arc a century, compared with 43.03 for Mercury. Although this value is only one quarter that of Mercury, it exceeds that of any other major planet. Thus according to J. J. Gilvarry (*Phys. Rev.*, vol. 89, p. 1046, 1953) observation of the motion of Icarus over the decades can yield a definite independent observational check of the precessional formulae of general relativity.

R. J. N.

Weather and the A-Bomb

After the recent series of severe storms and tornadoes throughout the United States and south-western Ontario, speculation as to the cause has led to the suggestion that atomic bomb explosions were responsible. But Weather Bureau experts in the United States have pointed out that a tornado is only a comparatively small by-product of general widespread stormy conditions. This general stormy condition releases energy equal to hundreds of thousands of A-bombs, but a tornado represents only 2 or 3 per cent. of the energy of an A-bomb, destructive as it may be. On the other hand, a thunderstorm is much more powerful and equals about 50 A-bombs. They too are products of general stormy conditions.

Another fact that supports the meteorologists' claims that the A-bomb debris is not responsible is that last year a similar number of A-bomb tests were carried out and only an average number of tornadoes occurred. It seems that an A-bomb does not produce the kinds of material which rainmakers claim influences the weather. The forces responsible for the tornadoes are many times more powerful than any man has yet devised.

B. R. C.

Is Man Alone in Space?

This is the question discussed by Loren C. Eiseley, an anthropologist, in the July issue of *Scientific American*. He states that the probability of manlike creatures existing on another planet is less favourable than it may seem. Even if there were another planet exactly like the earth in all its physical conditions, it could not be guaranteed that identically the same life would emerge.

R. J. N.

The Earth Is Warming Up

Man is slowly warming up the earth by adding to the atmosphere vast quantities of carbon dioxide from industry. This is the suggestion of Gilbert N. Plass of The John Hopkins University, made at a recent meeting of the American Geophysical Society. Plass recalculated the opacity of carbon dioxide to long-wave heat radiation and found it to be higher than previously believed. Thus the carbon dioxide in the air allows the short-wave heat to come into the atmosphere, but prevents the longer heat waves from escaping, acting like a greenhouse roof. Plass estimates that at the present rate the amount of carbon dioxide in the air will be doubled by the year 2080 and the resulting increase in the temperature of the earth would amount to four per cent. Plass also suggests that a decrease in carbon dioxide in the air may have been responsible for the formation of glaciers.

R. J. N.

Corrected Number to D.D.O. Communication

The paper by William R. Hossack, "An Oscilloscopic Microphotometer for use with Astronomical Spectrograms", page 195, is David Dunlap Observatory Communication Number 33 (instead of 32).

MEETINGS OF THE SOCIETY

AT TORONTO

April 7, 1953—The meeting was held in the McLennan Physics Laboratory. The First Vice-President, Mr. W. R. Hossack, was in the chair.

The following people were elected to membership in the Society (from Toronto unless otherwise stated): Wilbert C. Drury (Arthur); Arne Erlingsen; Miss Jane F. Roseborough. Mr. Eric G. Burnham (Barrie), transferred his life membership to the Toronto Centre.

The speaker of the evening, Dr. F. R. Britton, was introduced by Mr. Hossack. Dr. Britton is a lecturer in mathematics at McMaster University in Hamilton. The subject of his lecture was "Understanding Einstein".

The idea of relativity is as old as man. All measures of distance for instance, are relative, and before a measure can mean anything it must be referred to a definite rigid axis. Relativity involves motion.

The Greeks of ancient days knew about levers and some of the laws of statics. However their ideas, both right and wrong, were forced on scientists up until the time of Newton. Newton discovered that there were certain fundamental laws which nature obeyed, and he showed how they could be used. Two simple examples of these fundamental laws are:

1. If a body of mass M is acted upon by forces that have a resultant F, then the forces produce an acceleration a which is given by $F = M \times a$.
2. If $F = 0$, then $a = 0$.

Newton's ideas gained ground, and in France the great mathematician, Laplace, wrote his famous "Mécanique Celeste". This was the beginning of an era in which theory was rigidly tested by experiment, and if the theory was not confirmed, it was discarded. It was also an age when scientists tried to fit the laws of each branch of physics, into one general law. As examples of this one could point to the law of conservation of mass, the law of conservation of energy, or the principle of least action.

Now if a law is to be general, one would expect it to hold no matter where you are taking your frame of reference. This means we must consider the ideas of velocity and rest. If we take two frames of reference, one of which is in motion with respect to the other, Newtonian physics gives the law of the addition of velocities. For example, consider a man standing beside a train which is travelling 50 miles per hour, and a man on the train. They both observe an airplane which is travelling 200 miles per hour with respect to the man beside the train. But to the man inside the train, the airplane appears to be going only 150 miles per hour if they are travelling in the same direction. In 1887 Michelson and Morley showed that the measured velocity of light did not depend upon the motion of the source relative to the observer. This was contrary to the Newtonian law of additive velocities.

At the beginning of this century Einstein decided that the trouble lay in the Newtonian transformations (i.e. the equations of transformation for position and time for one frame of reference moving with respect to another). He applied the

Lorentz transformations, and found that now theory and experiment were in agreement. His theory also showed that no body can move with a velocity faster than the velocity of light. The theory is known as the special theory of relativity, and it applies to systems moving with constant velocities. For the past twenty years Einstein has been devoting his time to developing what is known as the unified field theory, in which he hopes to unify all physical laws.

The speaker was thanked for his very interesting lecture by Dr. A. L. Morgan. The meeting then adjourned.

BARBARA CREEPER, *Recorder.*

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INDEX TO VOLUME XLVII, 1953

A

Absorption of 10.7-centimetre Solar Radiation during Flare of May 19, 1951, *A. E. Covington* and *Helen W. Dodson*, 207.
Asteroid Icarus, 259.
Astronomical Developments in Australia, *A. R. Hogg*, 1.
Australia, Astronomical Developments in, *A. R. Hogg*, 1.
Australia, Radio Astronomy in, *J. L. Pawsey*, 137.

B

Bakos, Gustav A. (see Notes and Queries and Review of Publications).
Beals, C. S., The End of the World, 49.
Bruce Gold Medal Awarded to Harold D. Babcock, 176.

C

Calendar Confusions, India's, *M. N. Saha*, 97.
Chant, C. A., Edwin P. Hubble, 1889–1953, 225; (see also Notes and Queries and Review of Publications).
Chapman, J. H. (see Notes and Queries).
Cluster in Ursa Major, The Star, *R. M. Petrie*, 185.
Clute, Arthur R., Q.C., Death of, 39.
Copernican System to England, The Introduction of the, Thomas Harriot, 15.
Covington, A. E., Absorption of 10.7-centimetre Solar Radiation during Flare of May 19, 1951 (with Helen W. Dodson), 207; Three Most Intense Solar Noise Bursts on a Wave-length of 10.7 Centimetres, 106.
Crater, On the Origin of Chubb, 126.
Creeper, Barbara R. (see Notes and Queries).

D

Dalton, F. K., Star-dust from the Missing Planet, 10.
David Dunlap Observatory, Communications, No. 31, *Northcott*, 65; No. 32, *Heard*, 109; No. 33, *Hossack*, 195, 260; No. 34, *Sawyer*, 229; Notes, 95, 223.
Discovery and Interpretation of Nickel-iron Granules Associated with Meteorite Craters, The, *Lincoln LaPaz*, 191.
Dodson, Helen W., Absorption of 10.7-centimetre Solar Radiation during Flare of May 19, 1951 (with A. E. Covington), 207.
Dominion Astrophysical Observatory, Contributions, No. 30, *Underhill*, 153; Notes, 121, 255.
Dominion Observatory, Contributions, Vol. 2, No. 15, *Millman* and *McKinley*, 237; Notes, 21, 177.
Doppler, Christian Johann (1803–1853), The Centenary of, 175.

E

Earth is Warming up, The, 260.
Earth's Radius and the Moon's Distance, A New Determination of the, 38.
End of the World, The, *C. S. Beals*, 49.

F

Flare of May 19, 1951, Absorption of 10.7-centimetre Solar Radiation during, *A. E. Covington* and *Helen W. Dodson*, 207.

G

Globular Clusters, Thirty-eight New Variable Stars in Eleven, *Helen B. Sawyer*, 229.
Greenwich, The National Maritime Museum, 173.

H

H. D. 201626, a New High-velocity R-type Star, Note on, *Ruth J. Northcott*, 65.
Healy, Paul W., On the Identification of Terrestrial Meteorite Craters (with Lincoln La Paz and Frederick C. Leonard), 160.
Heard, John F., The Spectrum of Nova Scuti 1949, 109; (see also Review of Publications).
Hoffleit, Dorrit (see Notes and Queries).
Hogg, A. R., Astronomical Developments in Australia, 1.
Hogg, Frank S., Memorial Fellowship, 223.

Hogg, Helen Sawyer, (see Notes and Queries, Out of Old Books and also Sawyer, Helen B.).
Hossack, William R., An Oscilloscopic Microphotometer for use with Astronomical Spectrograms, 195, 260; (see also Notes and Queries and Review of Publications).
Hubble, Edwin P., 1889–1953, *C. A. Chant*, 225.

I

Identification of Terrestrial Meteorite Craters, On the, *Paul W. Healy, Lincoln LaPaz* and *Frederick C. Leonard*, 160.
India's Calendar Confusions, *M. N. Saha*, 97.
Is Man Alone in Space? 260.

J

Jupiter and the Sun, 127.

K

Kennedy, E. J. A. (see Notes and Queries).

L

LaPaz, Lincoln, The Discovery and Interpretation of Nickel-iron Granules Associated with Meteorite Craters, 191; On the Identification of Terrestrial Meteorite Craters (with Paul W. Healy and Frederick C. Leonard), 160.
Lectures before the Society:
EDMONTON—Telescope Making, *W. E. Mjolsness*, 40.
MONTREAL—Astronomy and Biology, *D. L. Thomson*, 41; Time—Past and Present, *W. H. Birtles*, 42; Starlight, *Anna J. MacPherson*, 43; Lunar Occultations, *C. M. Good*, 44; Flammarion—his Life and Work, *F. DeKinder*, 44; Planets for 1952, *Brian Cockhill*, 44; The Sun and the Aurora Borealis, *C. W. Gartlein*, 44; Measurement of Astronomical Distances, *E. R. Pounder*, 45; The Shaky Astronomy of Christopher Columbus, *E. Russell Paterson*, 45; Chubb Crater, *V. Ben Meen*, 46; The Astronomy of Kepler, *Henry F. Hall*, 128; An Astronomical Medley, *F. DeKinder, I. K. Williamson, E. E. Bridgen, Brian Cockhill* and *Henry F. Hall*, 128.
OTTAWA—Shooting Stars out of Season in Canada's Northland, *Warren D. Forrester*, 131; Exploding Stars, *J. F. Heard*, 131; Seismology and the Internal Structure of the Earth, *John Hodgson*, 132; Making and Using a Small Telescope, *W. M. Cameron*, 132; Solar and Lunar Influences on the Earth's Magnetism, *Julius Bartels*, 132; Keeping an Eye on the Time, *M. M. Thomson*, 134; Weather in the Arctic, *K. R. Greenaway*, 134.
TORONTO—The Sun's Activity from a Human Point of View, *Neal J. Heines*, 47; An Astronomer's Pilgrimage to Rome, *J. F. Heard*, 179; Grinding a 6-inch Mirror, *Bud Clark*, 180; Stereographic Photography of the Moon, *A. G. Cooper*, 180; Probing the Atmospheres of Supergiant Stars, *Andrew McKellar*, 181; Telescope Making, *Raymond Broadfoot, Norman Duhig, Tim Cooper*, 181; We Get to Know the Milky Way—How Astronomers Learn about our Galaxy, *Nancy G. Roman*, 182; Stellar Spectra, *W. R. Hossack*, 183; Understanding Einstein, *F. R. Britton*, 261.
WINNIPEG—Pictorial Creation of the Universe, *George R. Pratt*, 40; The Aurorae, *D. R. P. Coats*, 135; The Moon, *Alice Armstrong*, 183; Bird Migration, *A. G. Lawrence*, 183.
Leonard, Frederick C., On the Identification of Terrestrial Meteorite Craters (with Paul W. Healy and Lincoln LaPaz), 160; (see also Notes and Queries).
Library Hours, 256.
Lippincott, Sarah Lee, Red Dwarf Flare Stars, 24.

M

McIntosh, R. A., Your Piece of the Moon, 227.
McKinley, D. W. R., The Quadrantid Meteor Shower (with Peter M. Millman), 237.
Marion, Roland, Naturaliste Honoré par la Fondation Marie-Victorin, 203.
Mars, The Temperature of, 173.
Mayall, Margaret W. (see Variable Star Notes).

Mercury, Transit of, November 14, 1953, 220.
Meteor News, 29, 92, 162, 217, 253.
Meteor Shower, The Quadrantid, *Peter M. Millman* and *D. W. R. McKinley*, 237.
Meteor Spectra, Photographic, (Appendix 1), 217.
Meteorite Craters, The Discovery and Interpretation of Nickel-iron Granules Associated with, *Lincoln LaPaz*, 191.
Meteorite Craters, On the Identification of Terrestrial, *Paul W. Healy, Lincoln LaPaz* and *Frederick C. Leonard*, 160.
Meteorites, A Catalogue of Canadian, 29; Appendix, 164.
Meteorites, The Geographical Distribution of Canadian, 92.
Meteorites, Notes on Canadian, 162.
Microphotometer for use with Astronomical Spectrograms, An Oscilloscopic, *William R. Hossack*, 195, 260.
Millman, Peter M., The Quadrantid Meteor Shower (with D. W. R. McKinley), 237; (see also Meteor News and Review of Publications).
Moon, The Face of the, 38.
Moon, Your Piece of the, *R. A. McIntosh*, 227.
Moulton, Dr. Forest Ray, Death of, 84.

N

Naturaliste Honoré par la Fondation Marie-Victorin, *Roland Marion*, 203.
Night Vision, 222.
Northcott, Ruth J., Note on H.D. 201626, a New High-velocity R-type Star, 65; (see also Notes and Queries and Review of Publications).
Northern Lights Created in the Laboratory, 127.
Note on H.D. 201626, a New High-velocity R-type Star, *Ruth J. Northcott*, 65.
Notes from Observatories, 21, 95, 121, 177, 223, 255.
Notes and Queries, 36, 84, 126, 173, 220, 256.
Nova Scuti 1949, The Spectrum of, *John F. Heard*, 109.

O

Oke, J. B. (see Notes and Queries and Review of Publications).
Oscilloscopic Microphotometer for use with Astronomical Spectrograms, An, *William R. Hossack*, 195, 260.
Out of Old Books, 15.

P

Pawsey, J. L., Radio Astronomy in Australia, 137.
Perseid Observations, 1951 and 1952, Montreal, 217.
Perseid Observations, 1952, Regina, 253.
Petrie, R. M., The Star Cluster in Ursa Major, 185.
Planetarium, Mrs. Olive Grunow's, 36.

Q

Quadrantid Meteor Shower, The, *Peter M. Millman* and *D. W. R. McKinley*, 237.

R

Radio Astronomy and Galactic Structure, 175.
Radio Astronomy in Australia, *J. L. Pawsey*, 137.
Radio Telescope at Manchester, A New, 37.
Relative Abundance of Hydrogen to Helium in Stars, The, *Anne B. Underhill*, 153.
Review of Publications:
Aller, L. H., Astrophysics—The Atmospheres of the Sun and Stars, *J.B.O.*, 247.
Couderc, Paul, L'Expansion de l'univers, The Expansion of the Universe, *G.A.B.*, 212.
Harang, L., The Aurorae, *C.A.C.*, 122.
Hynek, J. A. (editor), Astrophysics, a Topical Symposium, *J.F.H.*, 124.
Kamp, van de, Peter, Basic Astronomy, *E.B.W.*, 34.
Kuiper, Gerard P. (editor), The Atmospheres of the Earth and Planets, *J.F.H.*, 122.
Lansau, L. and E. Lifshitz, The Classical Theory of Fields, *R.E.W.*, 96.
Lovell, Bernard, and J. A. Clegg, Radio Astronomy, *R.E.W.*, 123.
Mattersdorf, Leo, Insight Into Astronomy, *R.J.N.*, 35.
Moore, Patrick, A Guide to the Moon, *R.J.N.*, 171.
Porter, J. G., Comets and Meteor Streams, *P.M.M.*, 172.

Ryan, Cornelius, Across the Space Frontier, *J.F.H.*, 33.
Sternenhimmel, Der, 1953, *W. R. Hossack*, 124.
Tancock, E. O., Starting Astronomy, *R.J.N.*, 248.
Royal Astronomical Society of Canada, Annual Meeting, 67; New Address: 15 Ross Street, Toronto 2B, 127.

S

Saha, M. N., India's Calendar Confusions, 97.
Sawyer, Helen B., Thirty-eight New Variable Stars in Eleven Globular Clusters, 229; (see also Hogg, Helen Sawyer).
Solar Corona, The, 37.
Solar Noise Bursts on a Wave-length of 10.7 Centimetres, Three Most Intense, *A. E. Covington*, 106.
Solar Radiation during Flare of May 19, 1951, Absorption of 10.7-centimetre, *A. E. Covington* and *Helen W. Dodson*, 207.
Solar Spectrum, Photographs Obtained of Far Ultra-violet, 258.
Spectrum of Nova Scuti 1949, The, *John F. Heard*, 109.
Star Cluster in Ursa Major, The, *R. M. Petrie*, 185.
Star, Note on H. D. 201626, a New High-velocity R-type, *Ruth J. Northcott*, 65.
Star-dust from the Missing Planet, *F. K. Dalton*, 10.
Stars, Red Dwarf Flare, *Sarah Lee Lippincott*, 24.
Stars, The Relative Abundance of Hydrogen to Helium in, *Anne B. Underhill*, 153.
Symposium at University of Michigan, 221.

T

T Tauri and Associated Nebulosity, 256.
Thirty-eight New Variable Stars in Eleven Globular Clusters, *Helen B. Sawyer*, 229.
Three Most Intense Solar Noise Bursts on a Wave-length of 10.7 Centimetres, *A. E. Covington*, 106.

U

U.R.S.I. Meeting in October, 176, 257.
Underhill, Anne B., The Relative Abundance of Hydrogen to Helium in Stars, 153.
Universe, The Scale of, 174.
Ursa Major, The Star Cluster in, *R. M. Petrie*, 185.

V

Variable Star Notes, 23, 87, 117, 166, 213, 249.
Variable Stars in Eleven Globular Clusters, Thirty-eight New, *Helen B. Sawyer*, 229.

W

Weather and the A-Bomb, 259.
Weston, E. B. (see Notes and Queries and Review of Publications).
Williamson, Ralph E. (see Notes and Queries and Review of Publications).
World, The End of the, *C. S. Beals*, 49.

Y

Your Piece of the Moon, *R. A. McIntosh*, 227.

THE JOURNAL

OF

THE ROYAL ASTRONOMICAL SOCIETY OF CANADA

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PUBLISHED BI-MONTHLY
(*Six numbers per year*)

VOLUME XLVII, 1953

PRINTED FOR THE SOCIETY
15 ROSS STREET, TORONTO 2B

CONTENTS FOR VOLUME XLVII, 1953

I. JANUARY-FEBRUARY

		PAGE
Astronomical Developments in Australia	*A. R. Hogg*	1
Star-dust from the Missing Planet	*F. K. Dalton*	10
Out of Old Books (The Introduction of the Copernican System to England. V. Thomas Harriot and the Beginnings of Telescopic Astronomy in England)	*Helen Sawyer Hogg*	15
Notes from Observatories (Dominion Observatory, Ottawa)		21
Variable Star Notes	*Margaret W. Mayall*	23
Meteor News (A Catalogue of Canadian Meteorites)	*Peter M. Millman*	29
Review of Publications (*Across the Space Frontier* edited by Cornelius Ryan: *J.F.H.*; *Basic Astronomy* by Peter van de Kamp: *E.B.W.*; *Insight Into Astronomy* by Leo Mattersdorf: *R.J.N.*)		33
Notes and Queries (Mrs. Olive Grunow's Planetarium: *H.S.H.*; The Solar Corona: *R.E.W.*; A New Radio Telescope at Manchester: *R.J.N.*; The Face of the Moon: *H.S.H.*; A New Determination of the Earth's Radius and the Moon's Distance: *G.A.B.*; Death of Arthur R. Clute, Q.C.: *H.S.H.*)		36
Meetings of the Society—Winnipeg, Edmonton, Montreal, Toronto		40

II. MARCH-APRIL

The End of the World	*C. S. Beals*	49
Note on H.D. 201626, a New High-velocity R-type Star	*Ruth J. Northcott*	65
Annual Meeting of the Royal Astronomical Society of Canada: Reports of the Recorder, National Secretary, Librarian, Secretaries of the Centres, National Treasurer, Treasurers of the Centres, Officers for 1953		67
Notes and Queries (Death of Dr. Forest Ray Moulton: *Frederick C. Leonard*)		84
Variable Star Notes	*Margaret W. Mayall*	87
Meteor News (The Geographical Distribution of Canadian Meteorites)	*Peter M. Millman*	92
Notes from Observatories (David Dunlap Observatory)		95
Review of Publications (*The Classical Theory of Fields* by L. Lansau and E. Lifshitz, translated by Morton Hammermesh: *R.E.W.*)		96

III. MAY-JUNE

India's Calendar Confusions	*M. N. Saha*	97
Three Most Intense Solar Noise Bursts on a Wave-length of 10.7 Centimetres	*A. E. Covington*	106
The Spectrum of Nova Scuti 1949	*John F. Heard*	109
Variable Star Notes	*Margaret W. Mayall*	117
Notes from Observatories (Dominion Astrophysical Observatory, Victoria, B.C.)		121
Review of Publications (*The Aurorae* by L. Harang: *C.A.C.*; *The Atmospheres of the Earth and Planets* edited by Gerald P. Kuiper: *J.F.H.*; *Radio Astronomy* by Bernard Lovell and J. A. Clegg: *R.E.W.*; *Der Sternenhimmel*, 1953: *W. R. Hossack*; *Astrophysics, a Topical Symposium* edited by J. A. Hynek: *J.F.H.*)		122
Notes and Queries (On the Origin of Chubb Crater: *Dorrit Hoffleit*; Northern Lights Created in the Laboratory: *R.J.N.*; Jupiter and the Sun: *R.J.N.*; New Address: 15 Ross Street, Toronto 2B: *E. J. A. Kennedy*)		126
Meetings of the Society—Montreal, Ottawa, Winnipeg		128

IV. JULY-AUGUST

Radio Astronomy in Australia ..... *J. L. Pawsey* 137
The Relative Abundance of Hydrogen to Helium in Stars .. *Anne B. Underhill* 153
On the Identification of Terrestrial Meteorite Craters
Paul W. Healy, Lincoln LaPaz and *Frederick C.Leonard* 160
Meteor News (Notes on Canadian Meteorites) ..... *Peter M. Millman* 162
Variable Star Notes ..... *Margaret W. Mayall* 166
Review of Publications (*A Guide to the Moon* by Patrick Moore: *R.J.N.*; *Comets and Meteor Streams* by J. G. Porter: *P.M.M.*) 171
Notes and Queries (The National Maritime Museum, Greenwich: *B.R.C.*; The Temperature of Mars: *R.J.N.*; The Scale of the Universe: *G.A.B.*; Radio Astronomy and Galactic Structure: *B.R.C.*; The Centenary of Christian Johann Doppler (1803–1853): *C.A.C.*; Bruce Gold Medal Awarded to Harold D. Babcock: *R.J.N.*; U.R.S.I. Meeting in October: *J. H. Chapman*) 173
Notes from Observatories (Dominion Observatory, Ottawa) 177
Meetings of the Society—Toronto, Winnipeg 179

V. SEPTEMBER-OCTOBER

The Star Cluster in Ursa Major ..... *R. M. Petrie* 185
The Discovery and Interpretation of Nickel-iron Granules Associated with Meteorite Craters ..... *Lincoln LaPaz* 191
An Oscilloscopic Microphotometer for use with Astronomical Spectrograms
William R. Hossack 195
Naturaliste Honoré par la Fondation Marie-Victorin ..... *Roland Marion* 203
Absorption of 10.7-centimetre Solar Radiation during Flare of May 19, 1951.
A. E. Covington and *Helen W. Dodson* 207
Review of Publications (*L'expansion de l'univers* by Paul Couderc, *The Expansion of the Universe* by Paul Couderc, translated by J. B. Sidgwick: *G.A.B.*) 212
Variable Star Notes ..... *Margaret W. Mayall* 213
Meteor News (Photographic Meteor Spectra (Appendix 1), Montreal Perseid Observations, 1951 and 1952) ..... *Peter M. Millman* 217
Notes and Queries (Transit of Mercury, November 14, 1953: *R.J.N.*; Symposium at University of Michigan: *E.B.W.*; Night Vision: *J.B.O.*) 220
Notes from Observatories (David Dunlap Observatory) 223

VI. NOVEMBER-DECEMBER

Edwin P. Hubble, 1889–1953 ..... *C. A. Chant* 225
Your Piece of the Moon ..... *R. A. McIntosh* 227
Thirty-eight New Variable Stars in Eleven Globular Clusters
Helen B. Sawyer 229
The Quadrantid Meteor Shower ..... *Peter M. Millman* and *D. W. R. McKinley* 237
Review of Publications (*Astrophysics—The Atmospheres of the Sun and Stars* by L. H. Aller: *J.B.O.*; *Starting Astronomy* by E. O. Tancock: *R.J.N.*) 247
Variable Star Notes ..... *Margaret W. Mayall* 249
Meteor News (Regina Perseid Observations) ..... *Peter M. Millman* 253
Notes from Observatories (Dominion Astrophysical Observatory, Victoria, B.C.) 253
Notes and Queries (Library Hours: *William R. Hossack*; T Tauri and Associated Nebulosity: *B.R.C.*; U.R.S.I. Meeting Held in Ottawa; Photographs Obtained of Far Ultra-violet Solar Spectrum; Asteroid Icarus: *R.J.N.*; Weather and the A-Bomb: *B.R.C.*; Is Man Alone in Space? The Earth is Warming Up: *R.J.N.*; Corrected Number to D.D.O. Communication) 256
Meetings of the Society—Toronto 261
Index to Volume XLVII 263
Table of Contents to Volume XLVII ..... i to iv

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THE JOURNAL
OF
THE ROYAL ASTRONOMICAL SOCIETY OF CANADA

VOL. XLVII, No. 6 NOVEMBER-DECEMBER 1953 WHOLE No. 405

Articles PAGE

Edwin P. Hubble, 1889–1953 ..... *C. A. Chant* 225

Your Piece of the Moon ..... *R. A. McIntosh* 227

Thirty-eight New Variable Stars in Eleven Globular Clusters *Helen B. Sawyer* 229

The Quadrantid Meteor Shower *Peter M. Millman* and *D. W. R. McKinley* 237

Review of Publications

Astrophysics—The Atmospheres of the Sun and Stars by L. H. Aller (*J. B. O.*); Starting Astronomy by E. O. Tancock (*R. J. N.*) 247

Variable Star Notes ..... *Margaret W. Mayall* 249

Meteor News

Regina Perseid Observations ..... *Peter M. Millman* 253

Notes from Observatories

Dominion Astrophysical Observatory, Victoria, B.C. 255

Notes and Queries

Library Hours (*William R. Hossack*); T Tauri and Associated Nebulosity (*B.R.C.*); U.R.S.I. Meeting Held in Ottawa; Photographs Obtained of Far Ultra-violet Solar Spectrum; Asteroid Icarus (*R.J.N.*); Weather and the A-Bomb (*B.R.C.*); Is Man Alone in Space? The Earth is Warming Up (*R.J.N.*); Corrected Number to D.D.O. Communication 256

Meeting of the Society

At Toronto 261

Index to Volume XLVII 263

Table of Contents for Volume XLVII ..... i to iv

Address of Editors: David Dunlap Observatory, Richmond Hill, Ont.

Business correspondence and remittances should be addressed to J. H. Horning, Treasurer of the Society, 15 Ross Street, Toronto 2B.
$3.00 per annum, Single number, 50 cents.
Subscription to the JOURNAL is included in membership fee.